Forgiving Technology in Automated Office Buildings

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Abstract

A smart control device with an additional tool box which includes educational and information kits, called forgiving technology, has been developed in the EU funded project EBOB (2002-2004). It is meant for personal computers of the office workers enabling sustainable office working environments based on user behaviour. Careful design of the new prototypes for smart control devices has been accomplished with usability studies in different working environments in Sweden and in the Netherlands.

Promising results of the effect of the forgiving technology on the end-user behaviour are expected, which can result in ever more sustainable office buildings in the future. The possible changes in the office workers behaviour, which improve energy-efficiency are discussed in the paper. They concern both new office buildings and renovation projects.

Keywords: Office buildings, building automation, forgiving technology, end user control, energy saving, motivation tool

1. Background

This paper is drawing much from the EU Fifth Framework project EBOB, Energy Efficient Behaviour In Office Buildings (NNE5-2001-0263). The key focus of the EBOB project (www.ebob-pro.com) is on the combination of the human and social perspective with advanced modern control and ICT (Information and Communication Technologies) solutions. This is done in order to make energy efficient behaviour natural, easy and intuitively understandable for the end-users, and at the same time to achieve the most energy efficient solutions while

improving standards on indoor comfort in refurbished and new office buildings. The results gained due to this combining approach of human perspective and available new technology are called 'forgiving technology'.

The EBOB project creates new technical and socio-economic solutions to make energy efficient behaviour natural, easy and intuitively understandable for the end-users in refurbished and new offices. This will be achieved by starting from human perspective and use available and new technology (including ICT, smart control, user interfacing).

All energy use in a building interacts with each other in different ways. The focusing points in motivating the use of energy efficient solutions can be: information, user behaviour (end-user satisfaction, personal motivation), productivity, health aspects, indoor climate and tools (control systems and user interface). In this paper the building automation tools to be used to make the office space better regulated by the end-user and the end-user better informed of the influences of their acts are discussed. The more new knowledge is available the more productivity, health and indoor air aspects are talking for the need of flexible, adaptable and well regulated workplace and workspace. Furthermore, workers want to feel comfortable when working. The joy of work is gained out of empowerment, which forgiving technology allowing personal control is about. They are the basis for developing and using forgiving technology, but discussed in more detail in other context. First, this new way of controlling is introduced.

1.2 Definitions

Building automation is related to the phenomena of automated and intelligent buildings, which sometimes are mixed. There is no universal definition of intelligent buildings. However, certain consensus of the intelligent building concepts exists and efforts for agreement of the definition are available (cf. e.g. [4] and [18]). The latest of them is available of the automated buildings (Technology Roadmap for Intelligent Buildings, 2002). Also the ranking lists for the automated buildings are under development by the efforts of the CABA (Continental Automated Buildings Association, www.caba.org).

To differentiate intelligent buildings from other building concepts the forms of building intelligence[1] have been studied ([10], pp. 284-342). The forms of Building Intelligence (BI) are

[1] *Building-connectivity* (speaking and speech recognition including music and linguistics; user-connectivity and control: either personal or automatic or defined by the organisation in concern); *Building self-recognition* (building knows the state it is in; a kind of consciousness); *Spatiality* (a more conscious understanding of the spatial expression of the architecture, structures, interior design); *Building kinaesthetic* (a sense of change, active structures, moveable structures, furniture and equipment, adjustable technology or building services), and *Building logic* (embedded sensors to monitor the occupants' daily activities, combinativity).

derived from the forms of human intelligence[2] [11]. Automated or integrated buildings are intelligent buildings, where logic is the key attribute of the design, and the human ability of mathematical and logic intelligence is the motor for the solutions. Building automation is the leading application for this form of building intelligence. The other forms of building intelligence assist in making the building logic work for the benefit of the building occupants and occupant companies. Such assisting factors of intelligent buildings are (1) inter-connectivity by user interface (cf. also [12]), (2) building recognition which means that the building is aware of the status of building services and occupant activities, (3) spatiality which is related to the right locations of the building automation control units, and (4) the existence of active structures which make the building control come true.

Sustainability covers both the ecological issues and the human welfare. That is why the EBOB project and the development of forgiving technology have much to do with the Green building concept, which is also lacking a universal definition. Green buildings are according to the U.S. Green Building Council (USGBC), buildings that are environmentally responsible, profitable, and healthy places to live and work in (http://www.usgbc.org/). Furthermore, there is the concept of Healthy buildings, which is the continuation of the research of Sick buildings. The Sick building syndrome has been a concept to study phenomena of indoor air quality which affect people in a negative way causing syndromes such as back or head ache, irritation in throat or nose, difficulties with vision, etc. In healthy buildings indoor air is supportive to human health condition, abilities and activities.

1.2 State-of-the-art of Office Building Control

The need for energy renovation is urgent in such older office buildings where not only the envelope and the structures need repair, but also the control of HVAC systems is lacking. The change of the end-user behaviour can be an alternative strategy for reaching energy savings and still avoid high renovation costs. In the new office buildings that have been built by following the latest knowledge of the energy efficient and sustainable building technology and with the latest control technology, the correct energy efficient end-user behaviour is the only way of letting the technology prove its efficiency.

The end-user behaviour can be changed even without technology by informing and motivating. The automated control technology saves trouble caused by manual operations. However, still

[2] Seven forms of human intelligence by Gardner (1983 in [8], pp. 120–123, 1991 in [8], pp. 345–352, 1993 in [21], pp. 107–110, 1993 in [7], p. 28) are: Logical-mathematical, musical, linguistic, interpersonal, intrapersonal, visual-spatial and bodily-kinaesthetic.

personal involvement might be needed for special occasions or for personal needs differing from the standard norms of indoor climate.

1.3 Need of Personal Control

It is common knowledge among facilities managers that the possibility to influence one's work environment is one of the most important factors of the workspace design. A second one is the feeling that problems are taken care of, in one manner or another like change, repair, etc.

According to "What Office Tenants Want, the 1999 BUMA/ULI Office Tenant Survey Report" only 56 percent of all respondents are located in buildings with any of the intelligent features listed in the survey[3]. The questionnaire was sent to approximately 20,000 office tenants throughout the USA and Canada. Slightly more than 1,800 responses were received, primarily from principals or owners, executives, office managers, or department managers of the responding companies. Intelligent building features are much more prevalent in owner-occupied buildings ([24], p. 50).

In tenants' rating of the importance of intelligent building features to their business, but not currently available in their building no single intelligent building feature stands out, but six features are consistently among tenants' top three: high-tech and energy-efficient HVAC system, wiring for Internet access, wiring for high speed networks, LAN and WAN connectivity, fibre-optics capability, conduits for power/data/voice cabling ([24], p. 42). Automatic on/off sensor in the lighting system was not among the top six. The priority of the features changes when the tenants were asked to indicate whether they would be willing to pay additional rent to have those features: computer-related features, high-tech and energy-efficient HVAC system, security systems, telecommunications capability, and redundant power source ([24], p. 44).

The relatively high ranking of HVAC systems in this corroborates the importance tenants place on having a comfortable temperature in their office and having control over the office temperature ([24], p. 43).

[3] Fiber-optics capability, built-in wiring for Internet access, wiring for high speed networks, LAN and WAN connectivity, satellite accessibility, ISDN, redundant power source, conduits for power/data/voice cabling, high-tech and energy-efficient HVAC system, automatic on/off sensor in the lighting system, smart elevators that group passengers by floor designation, automatic sensor installed in faucets/toilets, compurized or interactive building directory

- According the IBs Survey, carried out in Finland in the Helsinki metropolitan area in twelve office buildings, the possibilities to control room temperature and lighting were not particularly good. They were evaluated with no high rates; room temperature with mean rate 6.2 (n^4=455) and lighting with mean rate 6.7 (n=455) ([10], pp. 242-243). The index was from 4 to 10, which was the best. In general the building and office automation was rated with 7.9 (n=286) in the intelligent buildings and with 7.5 (n=182) in the other high quality office buildings used as reference buildings to the intelligent ones ([10], p. 208). The respondents' evaluation was based on the effect of the building feature to the working efficiency. In this Finnish survey, there was found a statistically significant difference in the quality of technology between intelligent and other types of office buildings in whole, when all rates were summarised. However, this correlation was not found on controlling possibilities. The control was not better in the IBs than in other office buildings, although in some cases good personal control possibilities of indoor air had been in focus in the design of IBs.

The IBs Survey proved the work environmental control possibilities important, while those who had the chance to participate in design of their work environment evaluated the quality of it better than whose who could not, or had difficulties in influencing the design ([10], pp. 264-267). Besides, the majority of the respondents (60.4 per cent) could not even participate in the design.

Wyon (1999) states that no improvements in sustainability will occur unless users are provided with insight, information and influence. Insight includes an understanding of the context in which the behaviour and its consequences occur. Information includes feedback on current conditions such as room temperature and energy use. Influence includes providing means of affecting the relevant variables such as a user friendly, intuitively understandable user interface enabling users control of indoor climate parameters on the office room level.

The office workers and the facility management have to be involved for effective use of technology. Commitment and encouragement of the office workers and facilities managers to promote sustainability, and prevention of misbehaviour in use of technology are seen among other benefits yielded from technology as a new potential for even better energy efficiency in commercial buildings. It is not even enough to provide motivation in the form of rewards or sanctions. Occupants must also be empowered to adapt modified behaviour.

[4] number of respondents

2. Forgiving technology

Practice shows that many technical solutions for energy saving exist and are installed in many office buildings, but the real energy saving effects are not there. Reasons for these deviations can be found from: wrong combinations of building and installation technology; misinterpretation of operational staff; misunderstanding and energy inefficient behaviour of the office occupants [5]. The overall aim in the EBOB project is to save energy by:

- Integration of and interaction between behaviour aspects of office workers and energy saving technologies
- Prevent wrong combinations of building and installation technology
- Prevent misinterpretation of operational staff
- Prevent misunderstanding of office users
- Prevent energy inefficient behaviour of office users
- Produce (energy saving) systems, that seduce people to participate in energy saving behaviour
- To guide the design process towards energy saving solutions that considers human behaviour.
- Design guidelines.

2.1 Need of End-user Involvement

The work done in the EBOB project has resulted in the conclusion that a major factor explaining the bad energy saving results in office buildings is that users are misunderstanding how the HVAC systems work, e.g. not seeing the relationship between lowering temperature and raised energy use during Summer conditions and on the other hand the relationship between high indoor temperatures and raised energy use in Winter. Information of the effect of personal behaviour on the energy use of the building where the end-user is working is expected to result in less energy use.

Also, office workers are not always aware of the correct use of the control equipment, which causes energy losses. A user-friendly technology with informative control alternatives – the forgiving technology created by the EBOB project - could solve this problem (Figure 1).

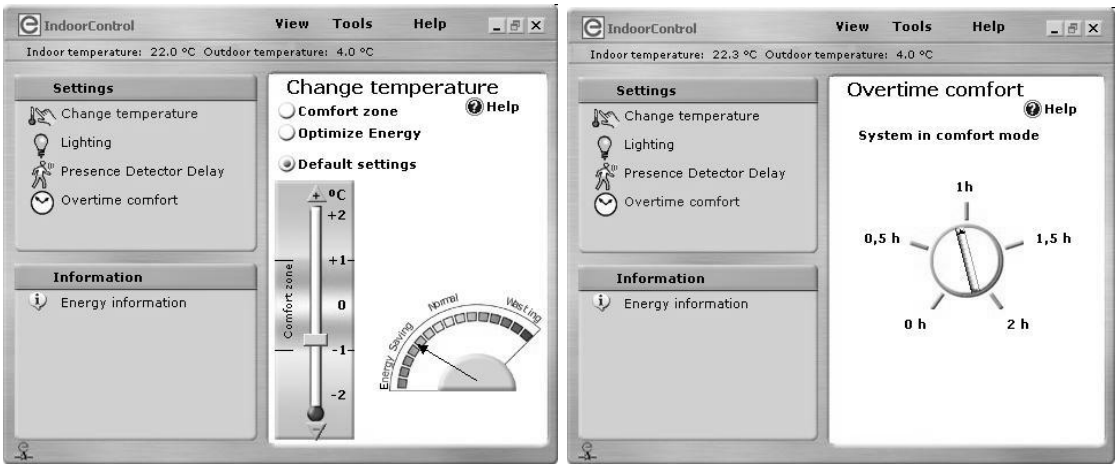

Figure 1: The control unit for forgiving technology. (TAC)

2.2 Technology

To allow the lowest energy consumption it is necessary that the building permits energy saving. A good starting point for energy optimisation of a building is that the building in itself is designed in an energy efficient manner.

In the modern office indoor environment the control of the room temperature, lighting and office automation equipment affect the energy consumption the most. In the EBOB project the work has been concentrated on the temperature and lighting regulation, and their co-operation. The temperature control involves heating and cooling and the lighting control includes the control of Venetian blinds. The system is generic and adaptable for other solutions in the future. The office automation as well as lighting is becoming energy-efficient. The energy losses from them or the use of free energy out of them will be reduced in the future.

Workers are a source of free energy. The occupancy of the office spaces varies during the working day. Working culture and the line of business influence the occupancy too. Occupancy has been discovered to be rather low for example in Northern American and English working cultures and higher for example in Finland. In England the occupancy can be as low as 45 % ([25] in [17], pp. 25) and in USA 33 % ([9] in [17], pp. 25). The occupancy of executives and executive assistants is 30 % and that of secretaries 60 % according to the British workplace consultants of DEWG [6]. However, Brill and Weidemann report higher occupancies in USA; managers 78 %, professionals 82 %, engineers and technical 80% and administrative 86 % (2001). According to the IBs Survey the occupancy of the Helsinki metropolitan offices is 87 % (62 % of the working time is spent at personal workspaces and 25 % in other spaces in the building) ([10], pp. 213, 228-231), and the occupancy of 67 % was found by Nissinen in Finland (2003, pp. 66). On the other hand, in the Netherlands the occupancies have been discovered to be low; 60 % of the office workers are in the office, and 35 % present at their

personal workspaces [20]. The presence detection is the tool to take the occupancy into account also in the EBOB project in addition to the end-user motivation to prevent energy losses to reduce unnecessary heating and lighting of empty spaces.

The indoor air quality is out of the scope of EBOB project, although the standard of it might have influence on the need of energy for ventilation. However, the regulation of the heating and air-condition systems done for keeping up the comfortable indoor air temperature affect also the indoor air quality; odours, particles, etc.

A set of EBOB rules for installations have been defined including the temperature control set points, heating and cooling operation times, etc. They are based on the data of the most effective heating and cooling periods of office buildings around the clock, use of heat recovery, new theories of the use of outdoor air temperature for dimensioning, etc.

The building manager chooses the buildings' temperature set point value. This set point can vary during the seasons and should be easy to change. It can also vary how much flexibility the building manager want to give to the users in the aspect of how many degrees of centigrades they should be able to change the temperature. The set-up of the steps a user should be able to change has to be done as well.

The EBOB solutions may include equipment with specified functionality and performance. It is important that these requirements are made clear so that the right type of equipment is actually purchased by the subcontractors, and not replaced by lower functionality or lower performance products. E.g. the contractors should be educated in these questions after signing the contract.

2.3 User Motivation

Influencing the behaviour of the actors can be done by; a) investment in energy efficient equipment (e.g. insulation, energy efficient equipment), b) more efficient management (e.g. thermostat setback when the office-worker leaves her/his room) and c) curtailment of needs or comfort. The multidisciplinary approach to workspace design and energy-efficiency is needed, because only rarely one idea alone is strong enough to solve several problems at the same time. Also the humble ideas of not knowing all – or even the possibility of not ever being able to cope with all phenomena of energy efficient workspace design – might be useful in design, in particular in the era of demand driven knowledge workplace design. For successful implementation of forgiving technology a supportive energy-efficiency of the building environment in the terms of the life-cycle of the building is needed.

Control is about possibilities and limitations [22]. The limitations of control can be classified in two main categories: external limitations and internal limitations. When actors experience that

they have external limitations they can believe for example that they cannot regulate the energy consumption of their room. External limitations are:

- The action is under the control (or responsibility) of other actors
- Economical limitations
- Limitations of social or work-related roles
- Time limitations
- There is no (realistic, good) alternative
- Lack of tools available
- Lack of information available.

When actors experience that they have internal limitations, they believe that their behaviour is not under their free will but under the control of an internal force. They are:

- Psychological aspects (personality, addiction, habit, lack of motivation)
- Cognitive aspects (lack of knowledge, biased mental models, lack of skill, has not thought about the issue before).

Motivation is based on the human tendency to use intelligence for the benefit of oneself and for satisfaction of one's needs, which can be described by the Maslow's Hierarchy of Needs according to his latest work [13]. A good environmental design cannot forget details that can clinch on the success or the fiasco of any solution, and an energy efficient forgiving technology respects the human needs, either separately each of them or in relevant combinations. There are a few interesting phenomena influencing the R&D work of products, which can be derived from the hierarchy of needs [12]:

- The human desire to easiness allows the automated functions.
- Variety of lifestyles makes the possibility to switch on manual mode necessary.
- Because of the need to know, occupants want to know what the automation is responsible for and what happens when a certain sound is heard or other activities take place.
- Such a human need as self-actualisation in the modern times goes hand in hand with the growing individualism influencing the design and research and technical development.
- Everybody wants to be good. A desired product provides the client with such an added value, which makes it possible.

To involve the service technicians, they need to be engaged in the creation of a new system. The main part of the life-cycle of a system is during the services and maintenance, after an

installation is made. Often developers forget this and adapt the system to be easy to install but not to maintain. We can see the system as a combination of different modules and each module needs to be administrated and maintained.

By choosing this method of working we will get continuous feedback also from the service technicians on how the functions work and if they are easy to maintain or change. Good input can be given by them since they are used to work with different user interfaces and can pick the best pieces from each.

Commissioning of the installation system when the building is first used is a very important factor that can influence the energy use and comfort. It is important that the service technicians receive sufficient and correct information and training. The user interface should therefore be intuitive to minimise training.

Still, the knowledge of the state-of-the-art of building is valuable for those in charge of the energy costs and the comfort level of end users is valuable information for the human resources departments of the occupants companies, and the future design of the control systems. The possibility to transfer that information further to those in need is a mean of improving motivation among FM personnel.

The motivation of the building owners and providers emerge from such company goals as [14]:

- the matter of interest in developing the relatively traditional building sector with acceptance and understanding of knowledge and means how to embed new and radical technology
- to polish the image of the companies working in the fields of building automation and building parts and products with a sustainable or energy-efficient technology
- the understanding of the business of buildings as a form of advantages input to the core process of a the occupant companies
- the interest in gathering end-user feedback (cf. e.g. [16]), and the consideration of the satisfaction of the user needs as the best business opportunity, because the problems of the client are solved
- correct information of the cost competitiveness of intelligent energy-efficient products without over estimating the R&D costs, etc.

2.4 User Interface

The control unit of the forgiving technology of the EBOB project has been designed using expertise in psychology, usability, industrial design and functionality (Figure 1). It resembles the manual control panels for heating and ventilation, but it is run on the screen of a personal

computer. In addition to the user friendliness of the control activities the forgiving technology is developed to give information to office workers to make them more aware of sustainability and motivated to behave energy-efficiently. Given information are of three kinds:

- General tips and knowledge
- Specific characteristics for this building
- Real-time feedback in the user interface.

Such factors that are related to the thermal comfort as clothing, so called climatisation[5] during longer warmer or colder periods or due to seasons will be taken into account with the information which will be given to the occupants via the user interface, as well as by education, energy saving campaigns and the EBOB toolbox.

Information and knowledge is only of real value in the process of decision making if it is Just in Time and Tailored to the demands of the end user. Most information systems fail because of the end user gets too much or irrelevant information. This means that the user has to be clear what his interest really is and for which purpose he or she needs information. In the EBOB InfoDoc, this will be solved by a users profile to be filled in before the request of information. Information about the person, interest, professional role, building phase and the organisation and the building will be required.

Such motivators can be mentioned [22] as:

- Comparisons with other's energy usage
- To see one's status compared to the average usage is useful
- To see one's status compared to one's earlier usage
- To display the usage in a graphical or in another easy-to-understand format,
- To display the energy usage in comparable terms which are easy to understand i.e. number of trees that can be saved by the energy savings etc.

Information and notes about energy usage should be short, practical but not too obvious. There also should be a link to further background information (e.g. scientific validity information). The energy related information should be shown already on the page where the users set the temperature so that it is up to the user to decide if he wants to perform the action or not (and not after doing it).

[5] with climatisation is meant the process while human body adapts to warmer or colder climatic condition either when moving to a warmer or colder climate or during spring and autumn

The system has to be able to give each type of user the appropriate information and steering option based on situation, role and authorisation. E.g., the office user will only see a certain portion of the information relevant to them in the “Information System” while the technician will be able to go deeper into the information, even read the manuals for the hardware etc.

3. implementation

The forgiving technology has been tested in a lab-environment at TNO in Delft in the Netherlands and in an office building of Kärnfastigheter in Helsingborg in Sweden. The rooms with and without forgiving technology are tested and compared (Figure 2). The evaluation of the tests has given feedback to the development of the prototypes of the forgiving technology.

The test results are also input to the activities of a simulation model and calculations which predict the success of the new technology under development. The calculation instrument of the energy consumption in one office building includes all kinds of influences such as sun, outdoor climate, design of the building, installations etc. The user of the instrument can define packages of all kinds of energy reduction measures.

Figure 2: The test room installations. For the end-users’ convenience the control of the heating fan coils and the lighting and their different combinations are in focus in the design and testing of forgiving technology.

The classification of the problems implemented [23]:

- Catastrophic: Can lead to a situation where the user has to suspend the use of the product. The problem is catastrophic when it prevents the user from completing his task, causes distortion of information or when it is related to a crucial function. Has to be eliminated.

- Severe: Significantly disrupts the efficient use of the product or slows it down remarkably. Prevents the learning of its functions. Should be corrected.
- Major: Moderately disturbs the efficient use of the product or prevents the efficient use of a limited part of the product. Recommended to be corrected.
- Minor: Disturbs the efficient or fluent use of the product to some extent, generally however within a quite restricted situation. Worth correcting if it is not too difficult.
- Cosmetic: Doesn't directly affect the use of the product, but it might affect the user's experience about the reliability and convenience of the product.
- Technical Problem: A feature of the prototype or a programming- or functional error discovered during the usability assessment, which affects the usability of the product. Is likely to have to be corrected before the implementation of the product.
- User Expectation: User's wish for something generally to be added, but isn't really a usability problem.

In an ideal situation, the occupant's role in controlling energy use and indoor climate is overridden by the system in all aspects except for those in which they need to have the control. It is ideal because it would optimise the comfort and energy use, and at the same time the users do not have to worry about issues they do not want to be concerned with. Expert knowledge gives as an example of this the occupants disability to perceive or not wish to influence normal changes on humidity or air quality parameters as carbon dioxide levels.

However, there are some parameters or installation aspects that cannot be completely automated, parameters that the users want and need to control at least in some aspects [23]. These are:

- Indoor temperature (in a range of a few degrees),
- Lighting (can be partly automated),
- Being able to keep doors and (and in some cases) windows open and
- Shutting down the computer (can be automated in some cases).

In conclusion, these above mentioned situations are the most important cases where the incorrect uses are relevant [23]:

Misuse of temperature controls; four main reasons why the temperature is not always good enough:

- The temperature controllers are too difficult to use and understand.
- The natural feedback (the actual change in temperature) is delayed.
- People have wrong mental models about good indoor temperatures.

- The space is shared (e.g. open office space or a meeting room)
- Incorrect use of lighting, doors and windows, and the personal computer.

The common wrong mental models about the indoor temperatures and air quality are typically the following [23]:

- Most of the people seem to think that a good indoor temperature is always the same independently of other conditions (e.g. season).
- Some occupants think that comfortable indoor temperature is higher in the Winter than during the Summer (which is completely opposite of the reality).
- Many people think that a good temperature is always somewhere between 19-21 degrees of Celsius, which is often uncomfortably cool during the Summer times.
- The users want to change the temperature, or maintain it constant, it may be difficult if they have a door or a window opened.
- The outdoor air quality is also some times worse than the filtered indoor air, which is not always understood by many occupants.

The problem of shared spaces is inherently very tough issue to solve, because all individual preferences and differences cannot be matched. However, the problem is bigger, if there are temperature controllers available. This can produce constantly changing temperatures, if different occupants are often trying to change the temperature according to their own preferences. This kind of situation is uncomfortable for all occupants. It is probably recommendable that in shared spaces the temperature is automated according to the average preferences. In that case at least the majority of the occupants are not complaining. The rest of the occupants might be educated to control their thermal comfort by clothing.

Similar arguments can be found from lighting control as well as myths about computers and energy consumption 1[23]:

- One typical myth is that putting the light off and on too often consumes more energy than it saves.
- It is quite misleading to believe that shutting down the computer shortens the life span of the hard disks in general or shortens the life of the common hard disks.

The potential of computer energy saving settings depends on the computers and on the software used. The existing potentials are not often used because of a lack of time, knowledge or interest.

4. DISCUSSION

It is only recently that smart control technology for better indoor air quality took place, and now it is there for both better indoor air quality and better energy efficiency in buildings. In addition many papers claim that well being and productivity are related to indoor comfort and individual controllability if only without any exact measurements of the effect of them over productivity ([1], Farshchi and Fisher in [3], p. 60, [10], p. 264-268.).

The IBs Survey shows that the office workers (in 1994) wanted to have a building manager to help with facilities management rather than building automation systems (Table 1.).This is challenging for the R&D and testing of forgiving technology. Is current building automation technology able to please the customer needs in the office work environment?

The EBOB forgiving technology is an interactive system with several optional control possibilities, which are very different from fully automated systems dominating the end-user. Unknown in this phase of work when the last year of the three year project is left, is if the interaction between the end-user and the control technology can be used in the indoor air and lighting control satisfactory enough in the end-user point of view.

Table 1:. Man or machine the IBs Survey by VTT in 1994 [15].

Percentages of the respondents, n=514 (office workers)	**Favouring manual operation**	**Favouring automated operation**	**Both**
Text editing by secretary or text editing programs	27	71	2
Copying by a service or from personal computer	37	61	2
Information transfer in meetings or by phone, by emails and via video-conferencing	37	54	9
Image handling by draftsman or image handling programs	37	57	6
Information service by informaticians or from databases	42	51	7
Secretary answers the phone or use of answering machine	70	28	2
Education by personally attending seminars or by interactive multimedia	84	11	6
Building management by building managers or by building automation	**92**	5	3

5. Conclusions

For the time being the conclusions regarding the development and testing of the forgiving technology is based on the first version of the prototype. New software is now running in the test sites and the user feedback from the second prototype of forgiving technology is expected in summer 2004 for more evidence and indications. So far the results are very promising and the belief of the project participants is that the empowerment of the end-users with forgiving technology as developed in the project gives substantial benefits both in terms of savings of energy and more motivated and productive users.

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